Understanding Antibiotic Use for Pig Farming in Thailand: A Qualitative Study

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Abstract

Background: Antimicrobial resistance (AMR), recognised as a serious and growing threat to global health, is driven by antibiotic use. Understanding factors influencing antibiotic use is essential to design and implement effective interventions to reduce unnecessary antibiotic use and AMR. This study aims to explore the practices and views of the key actors associated with the use of antibiotics for pig farming in Thailand, from local farmers to officers in central government institutions. Methods: A total of 31 in-depth interviews were conducted with pig farmers (n=13), drug retailers (n=5), veterinarians (n=7), and government officers (n=3) and representatives of health professional councils (n=2). Direct observations were conducted in pig farms. Thematic analysis based on practices, views and interests of actors regarding antibiotic use in pig production in Thailand. Results: There are various factors influencing the use of antibiotics. The factors may trigger greater antibiotic use including lack of knowledge and awareness about antibiotics and AMR, economic incentives, and loose regulatory frameworks. Farmers considered that antibiotics are necessary to maintain animal health, prevent and control diseases, and ensure economic gains, so using antibiotics was considered a worthwhile investment in pigs. There was limited information about antibiotic use in the curriculum and lack of clinical practice guidelines for health professionals. Veterinarians faced challenges in diagnosis and lacked antibiotic prescribing guidelines. Pharmaceutical companies applied market promotion strategies to increase sales; and used professionals as mediators with farmers. There was no control of antibiotic sale and prescription via the regulatory environment. The national policy on AMR could be facilitating factor to optimise use of antibiotics but its influence was weak relative to other influences which favoured antibiotic use. Conclusions: Our study highlights the need to improve antibiotic use in pig production in Thailand. Access to veterinary services and reliable information about animal health needs to be improved among farmers. Innovative low-cost investment in biosecurity could improve farm management and decrease reliance on antibiotics. Developing professional training and clinical guidelines, and establishing a code of conduct, are needed to improve practices in antibiotic prescription and sale amongst health professionals and industry.

Introduction

Antimicrobial resistance (AMR), recognised as a serious and growing threat to global health, is driven by antibiotic use not only in humans but also in animals. In many countries, antibiotics are used to promote growth in livestock in addition to treating, preventing and controlling infections (1). This inappropriate use has potential risks to human health which need to be controlled (2–4).

In pigs, both commensal and pathogenic bacteria are becoming more resistant to common antibiotics due to increased use of antibiotics (5,6), particularly in low- and middle-income countries (LMICs) (7,8). Of particular concern is the emergence of resistance to those antibiotics categorised by WHO as Critically Important Antimicrobials (CIA) such as colistin, which are reserved for treating the most severe human infections (9).

The factors influencing antibiotic use in pig production have been studied in various settings (10–16). A recent systematic review showed that antibiotic use in the pig sector was related to the phase of production such as antibiotics were commonly used during suckling and post-weaning periods; and farm management practices including density of pigs in farm had a positive association with the use of antibiotics (16). Apart from the factors associated with pig production, knowledge and understanding of antibiotics among farmers are also important. A few studies found that farmers have limited knowledge of the names of antibiotics or clinical indications for use (10,12). Poor knowledge of antibiotics was found in Chinese farmers, along with a high level of improper use of antibiotics (11). Legislation and government policies play an important role in the practices of both farmers and veterinarians. In five European countries, farmers were worried about legal restrictions to reduce antibiotic usage, particularly requirements in pig husbandry which were associated with high costs (13). In another survey in Europe, legislation regarding veterinary drugs was perceived to influence prescribing practices more than the price of antibiotics, owner demand or clinical guidelines (14); veterinarians also believed that mandatory interventions have the greatest impact on reducing antibiotic use in livestock (15).

Despite these studies, our knowledge of practices influencing the agricultural use of antibiotics is still limited, especially in LMICs where there is little capacity to conduct research and evaluation. This study aimed to explore the practices and views of the various categories of key *actors* associated with the use of antibiotics for pig farming in Thailand, from local farmers to officers in central

government institutions. Understanding factors influencing antibiotic use is essential to design and implement effective interventions to reduce unnecessary antibiotic use and AMR.

Materials And Methods

Study design

This qualitative study used interviews with farmers and other actors, and farm observations, to explore views and practices on antibiotic use. The study was conducted between March 2018 and January 2019 in a province in the central region of Thailand, which accounts for about 20% of annual domestic pig production and hosts different production systems, from smallholders to large agro-industrial conglomerate farms. The study was part of a larger study which included a cross-sectional survey of antibiotic use of pig farmers in six sub-districts with the highest number of pig farms in the province (17).

Study context

The Thai agricultural sector accounts for approximately 10% of GDP (USD 42 billion in 2018) with livestock production, including pigs, contributing around USD 400 million (18). In 2017, nearly 19.5 million pigs were raised and slaughtered, mainly for the domestic market (19,20). Since the 1960s, pig production in the country has increasingly shifted from smallholder farming for household consumption to intensive commercial production for growing urban markets. The sector is dominated by a small number of large agro-industrial conglomerates although a diversity of production systems coexist (21), with different levels of bio-security (22). In smallholder farms, pigs receive a variety of feed including leftover food and vegetables and there is potentially limited access to veterinary services and antibiotics, while in commercial farms, antibiotics are commonly applied to whole groups of pigs through medicated feed, either commercial or farm-mixed. In 2017, it was estimated that about 3,690 tonnes of antibiotics were given to food-producing animals, of which about 50% belonged to the CIA group (20). To improve farm management, the Department of Livestock Development (DLD) grants Good Agriculture Practices (GAP) certificates to farms which comply with standards of animal husbandry (23). The GAP-certified farms are required to have designated veterinarians to supervise the control, prevention and treatment of animal diseases. The use of antibiotic should be authorised by those veterinarians. GAP certification is voluntary.

Research design

This qualitative study was conducted between March 2018 and January 2019 in a province in the central region of Thailand, which accounts for about 20% of annual domestic pig production and hosts different production systems, from smallholders to large agro-industrial conglomerate farms. Data collection for the qualitative study primarily involved in-depth interviews with farmers to explore views and perceptions associated with antibiotic use. Farm observations were also conducted to gain a better understanding of practices and farm management. In order to capture the diversity of perspectives, interests, and incentives which may influence antibiotic use, veterinarians, drug retailers, industry representatives, and government officers were also interviewed.

Participant selection

The pig farmers in this study were recruited from a cross-sectional survey of pig farms about antibiotic use (17). Of 102 farmers contacted in the studied area, 84 farmers agreed to join in the survey. We subsequently asked for their willingness to provide information via in-depth interview at their farm and 11 out of the 84 farmers agreed to participate in interviews. Two farmers who did not use antibiotics were purposively selected through a snowball sampling technique.

Animal drug retailers, food animal feed industry veterinarians and government officers were also purposively selected for interview. Animal drug retailers who were working in the study area were identified by farmers. Relevant organisations such as government authorities responsible for antibiotic control in national and provincial levels, the animal feed mill association, veterinary association, and health professional councils were asked to propose lists of their staff or members who could provide information about the use of antibiotics in pig production. The first author contacted all potential informants to ask if they were able and willing to participate in the study.

Data collection

Drawing from previous studies (10,24), the guidelines for the interviews with farmers covered: a) farm management, b) animal health and productivity, c) the pork market, d) interactions with veterinarians and pharmaceutical companies, and e) regulation and policy regarding antibiotics. Interviews with other categories of participants were tailored to their role and experience with pig farming and the use of antibiotics. Interviews were conducted face-to-face by the first author and lightly structured to let participants express their own views. The interviews with pig farmers were conducted at their farms, or at a health centre; while animal drug retailers and veterinarians were interviewed outside their shops and offices, and government officers and representatives of health professional councils and veterinary association were interviewed in their offices. On average, they lasted 120 minutes. Written field notes were taken and, where permission was gained, the interview was audio-recorded.

After the interviews with pig farmers, the researcher sought permission to conduct observations in the farm. During the observations, the researcher examined activities of farm workers, the feed labels, the medicines used by farmers, and general sanitation and farm management. In addition, the researcher walked through the farms and engaged in casual conversations with farmers and farm workers. To prevent cross-infection between farms, farm visits were restricted to no more than one a week.

Data processing and analysis

The interview audio recordings were transcribed verbatim and anonymised by the researcher (AL). Data were imported into the software NVivo12 for qualitative analysis. The researcher (AL) generated initial codes after reiterative reading of the transcripts. The field notes were reviewed in parallel with the transcripts. Then two researchers (AL and VT) organised and formed themes and sub-themes. To reduce subjective bias, the researchers (AL, ML, SY and VT) critically discussed interpretation throughout coding and theme development. In thematic analysis, themes are considered robust when they are distinct and cohesive with respect to the coded extracts and the entire data set (25). Thus, researchers assessed consistency and accuracy within interviews and across respondents by triangulation.

Ethical considerations

Ethical approval was granted by the Institute for the Development of Human Research Protection at the Ministry of Public Health, Thailand (reference number: IHRP2018007) and the London School of Hygiene and Tropical Medicine (reference number: 14860). Informed consent was obtained for all interviews. No names or affiliations of the respondents are reported in results.

Results

Respondents’ profiles and studied farms

Table 1 shows the profiles of the 31 participants interviewed. These comprised thirteen farmers, five animal drug retailers, eight food animal industry veterinarians, and six participants consisting of government officers responsible for antibiotic control, and representatives of health professional councils and the veterinary association.

Table 1
Respondents’ profiles

	Total	Gender		Age	Work experience
		Male	Female	(years; mean, range)	(years; mean, range)
1. Pig farmers	13	10	3	47.9 (35–66)	22.7 (5–50)
2. Animal drug retailers	5	3	2	40.8 (30–48)	15.1 (3.5–24)
3. Veterinarians	8	5	3	49 (31–61)	22.8 (5–37)
4. Government officers	3	2	1	37.3 (31–50)	10 (4–20)
5. Representatives of health professional councils	2	1	1	62.5 (60–65)	10 (8–12)
Total	31	21	10	47.8 (30–66)	16.1 (3.5–50)

Table 2 shows the diverse characteristics of the 13 farms, ranging from a smallholder farm with only one sow and five piglets, to a large commercial farm with more than ten thousand pigs and monthly income of more than US$15,900. Six farms were DLD GAP-certified, one was a contracted farm and five farms were members of a cooperative. Three were fattening farms and ten were farrow-to-finish farms. Two farms were antibiotic-free. Of the thirteen farms, six allowed researcher observations; these farms ranged from a backyard farm with only six pigs in a small pen (3 × 3 meters) to a large farm with about 5,000 pigs.

Table 2
Farm characteristics

	Size of farm	Number of pigs		GAP farm [a]	Contracted farm	Member of coopera-tive	Type of farm [b]	Income from selling pigs per month (US$ 1 = 31.5 THB)	Use of anti-biotics	Farm visit
		Number of sows	Number of other pigs							
1	Smallholder	1	5	N	N	N	FtoF	<US$317	Y	Y
2	Smallholder	5	25	N	N	N	FtoF	<US$317	Y	N
3	Smallholder	4	12	N	N	N	FtoF	<US$317	Y	N
4	Commercial (S)	0	60	N	Y	N	Fattening	US$317-1,590	Y	Y
5	Commercial (S)	10	90	N	N	N	FtoF	US$3,170 – 15,900	Y	N
6	Commercial (S)	40	195	N	N	Y	FtoF	Not willing to respond	Y	N
7	Commercial (S)	0	500	Y	N	Y	Fattening	Not willing to respond	Y	N
8	Commercial (S)	50	200	Y	N	N	FtoF	US$3,170 – 15,900	N	Y
9	Commercial (M)	140	600	Y	N	N	FtoF	US$3,170 – 15,900	Y	Y
10	Commercial (M)	600	3,000	Y	N	Y	FtoF	US$3,170 – 15,900	Y	N
11	Commercial (M)	0	5,000	Y	N	N	Fattening	US$3,170 – 15,900	N	Y
12	Commercial (L)	2,000	> 10,000	N	N	Y	FtoF	>US$15,900	Y	Y
13	Commercial (L)	2,500	> 10,000	Y	N	Y	FtoF	>US$15,900	Y	N

a: GAP: Good Agriculture Practice; b: FtoF: Farrow-to-finish farm

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Use of antibiotics in pig production: experiences and perspectives of different actors

There were diverse and at times competing views about the use of antibiotics in pig production. The analysis of the interviews revealed wide divergencies between the interests and incentives of different actors in the agricultural sector – the pig farmers, health professionals, and the pharmaceutical industry, considered in turn below.

Pig farmers

Perceived health benefits and economic value of antibiotics

All the pig farmers interviewed believed that some form of medication, including antibiotics, was necessary to maintain animal health, and control and prevent disease.

"Medicine (antibiotics) are really important for my farm. Without medicine, my pigs would be very ill. Antibiotics medication protects my pigs from becoming worse." [Fs02, female, > 40 years old, non-GAP farm]

"I have to use antibiotics for my pigs. At the suckling and nursery stages, the piglets are so vulnerable. I applied antibiotics 100% to them. Whether or not they are sick, I need to apply antibiotics for prevention…" [Fc07, male, > 50 years old, GAP-certified farm]

In their experience, antibiotics reduced pig mortality, hence minimising production loss, while the cost of antibiotics was a small portion of production cost. One farmer estimated that medicated feed cost only 2.7% more than non-medicated feed and administering antibiotics to the herd via medicated feed was less labour intensive than individual treatment.

"I think that antibiotic use is a cheap solution; and affordable… For me, the cost of production is not different whether we add medicine (antibiotics) or not. For example, now the cheapest medicine is Chlortetracycline. For nursery pigs, the feed mixed with Chlortetracycline was BHT 22.60 compared with BHT 22 per kilogram of regular feed. It doesn't add much to my cost." [Fc12, male, > 30 years old, non-GAP farm]

Pig farmers' knowledge of antibiotics and awareness of AMR

Levels of knowledge about antibiotics differed greatly amongst pig farmers. None of the three smallholder farmers understood the word "antibiotic" ("*Ya-Kha-Chue*", "*Ya-Khae-Akseab*", "*Ya-Pati-Cheewana*" in Thai) while some commercial farmers showed some level of understanding about antibiotics and could differentiate between antibiotics and other medicines. Most commercial farmers said they used antibiotics according to the indications on the package labels or pharmaceutical detailers' recommendations. However, their practices, for example using high potency antibiotics without clinical justification, appeared to contradict guidelines and recommendations:

"For the treatment of common diseases, I will apply a broad-spectrum antibiotic such as amoxycillin. If there is no improvement, I will then change to cepha(losporin), cefo(xamine) or enrofloxacin…I believe in the higher potency antibiotic. If there is no price difference between the two antibiotics, I must select the higher potency one." [Fc12, male, > 30 years old, non-GAP certified farm]

Most commercial farmers were defensive when the researcher raised the issue of AMR and the potential association between antibiotic use in livestock and resistant bacteria. They said that they were not aware that their practice might be associated to AMR emergence and spread.

"*Our pigs are good, clean, no medicines (antibiotics). I don't know resistant pathogens, but I don't think that we (farmers) are involved in it.*" [Fs03, male, > 40 years old, non-GAP certified farm]

Farm management

All farmers agreed that good farm management was key to animal health and consequently reducing the need for antibiotics. However, most farmers were concerned that good farm management required a large investment to improve infrastructure and biosecurity. A closed system housing of 300 m^2 cost more than 1 million THB (US$ 31,700).

"I give more attention to prevention than treatment. Water quality, low pig density and good air ventilation are essential for healthy pigs…. When they (pigs) are healthy, I don't need to use antibiotics." [Fc09, female, 45 years old, GAP farm]

"…the closed system can improve my pigs' health, minimises introducing pathogens to the farms and reduces the use of antibiotics. But this adds to cost of production. I can't afford to invest." [Fc06, male, > 40 years old, non-GAP-certified farm]

The DLD requires GAP-certified farms to have a farm veterinarian who regularly supervises animal health and antibiotic use programs; only a few farms in the study had the certification. The two antibiotic-free farms in this study were GAP-certified farms. The farms had high bio-security measures such as mandatory changes in clothing and boots and spraying all vehicles with a disinfectant before entering the farm (Box 1).

Lack of market demand and production mechanism for antibiotic-free pork

Some farmers expressed concern that there was no market demand for antibiotic-free pork. A farmer from an antibiotic-free farm reported that he had to himself find a market for his products. In addition, most slaughterhouses in Thailand do not separate antibiotic-free pork and other pork, causing possible contamination. Therefore, antibiotic-free standards cannot be met due to the potential contamination. However, livestock production from large companies may not face this problem since they usually control the whole supply chain, from farm, slaughterhouse to retail outlet.

Health professionals

Veterinary services

Antibiotics and other medicines used in farms were provided by different categories of health professionals working in the agricultural sector, including veterinary practitioners, veterinarians in pharmacies, representatives of pharmaceutical companies and animal husbandry specialists.

Most farmer participants in our sample relied on the advice of veterinarians regarding the selection and use of antibiotics. However, only one out of 13 farms in the study hired a full-time licensed farm veterinarian. Most commercial farmers used so-called “farm consultants” who were veterinary professors and representatives of pharmaceutical companies. Smallholder farmers had limited access to veterinary services, due to lack of public veterinary health facilities and district veterinarians, while most animal clinics served companion animals only. All smallholder farmers received advice on antibiotic use from lay people (who had animal health knowledge or experience) or pharmacies where they purchased antibiotics.

Health professionals’ competency

Interviews with key informants from the veterinary and pharmacy councils confirmed that courses on the prudent use of antibiotics were not included in the veterinary and animal husbandry curriculum, while the pharmacy curriculum did not cover use of antibiotics in animals. A key informant from a veterinary association mentioned that their association provided in-service training and clinical practice guidelines for some disease management. However, veterinarians expressed concern over lack of clinical practice guidelines, lack of protocols for sample collection, difficulties in laboratory sample transportation, delays in receiving lab results and high cost of bacterial culture and drug sensitivity testing.

Awareness of AMR

Most veterinarians were aware of government policy on reducing the use of antibiotics. However, some of them became defensive when the researcher raised the issue of AMR. They said antibiotics were used only when necessary, and not indiscriminately as perceived by the public.

“Of course, we use a large amount of antibiotics in livestock, but I believe that other sectors such as doctors, pharmacists and orchards use more. Patients who don't take the full dose are the cause of the resistant bacteria … I don’t believe that people will die from AMR transmitted by animals.” [V07]

The pharmaceutical industry

Antibiotic sales and market promotion

All commercial farmers stated that it was easy to buy antibiotics through on-site sales by representatives of pharmaceutical companies. Respondents from the three commercial farms reported that representatives of pharmaceutical companies promoted the sale of antibiotics and other medicines through discounts and customer rewards such as offering leisure travel.

Relationship between pharmaceutical company and farmer, and academia

Some farmers reported that pharmaceutical company representatives offered veterinary services and non-technical incentives to farmers such as meals, and also built personal relationships, which encouraged the use of antibiotics. In addition, two farmers described a close relationship between pharmaceutical company representatives and some veterinary professors. Farmers felt

“coerced” to use antibiotics from the company recommended by professors who in turn were reportedly sponsored by the company which provided equipment to their faculty, or honorariums:

“All pharmaceutical companies offer sales promotions. You can choose either 10% discount or international leisure travel awards. In previous years, I have travelled to the US, Iceland, Spain, Japan. I feel like I have to order more medicine to gain the award.” [Fc13, male, > 40 years old, GAP certified farm]

"The representatives of pharmaceutical companies started to offer me a meal or liquor...sometime, he (representative) said please order to help him achieve his sales target…. Most lecturers are affiliated with pharmaceutical companies. They support lecturers by providing equipment to the university. I appreciate help provided by lecturers but need to follow what drugs are suggested." [Fc10, male, > 40 years old, GAP certified farm]

Potential areas contributing to the use of antibiotics in pig production

Figure 2 sets out the areas that appeared to be either conducive, or not conducive, to the optimal use of antibiotics according to three key groups of people and organisations who represent them - pig farmers, health professionals, and the pharmaceutical industry, involving with the use of antibiotics. Nine themes were identified through analysing and categorising information in the in-depth interviews (Table A1).

Firstly, farmers believed that antibiotics were necessary to maintain animal health, prevent and control diseases, and ensure economic gains, so using antibiotics was considered a worthwhile investment in pigs, especially when farmers lacked knowledge and awareness about the link between antibiotics and AMR. Secondly, there was limited information about antibiotic use in the curriculum and lack of clinical practice guidelines for health professionals. Veterinarians also faced challenges in laboratory testing and diagnosis. Thirdly, pharmaceutical companies applied market promotion strategies to increase sales; and used professionals as mediators with farmers. There was no control of antibiotic sale and prescription via the regulatory environment. This was compounded by limited public veterinary services to support farmers and the limited role of GAP-certified systems. Alternatives to antibiotics were not available and there was little market demand for antibiotic-free pork.

Figure 2 Potential areas contributing to the use of antibiotics in pig production: roles and perspectives of three actors in a regulatory environment.

Discussion

This qualitative study has deepened our understanding of the complex set of factors influencing the use antibiotics. Factors that are conducive to optimal use of antibiotics in pigs include good farm management and biosecurity, yet optimal use at farm-level may not always lead to optimal societal outcomes on AMR management at societal level – a classic issue of an externality. In addition, the lack of knowledge and awareness about antibiotics and AMR, economic incentives, and a loose regulatory framework creates an institutional environment of misunderstanding and could lead to the misuse or abuse of antibiotics in the broader context of managing AMR.

Although farmers recognised that good farm management, for instance, safe and clean housing, good hygienic quality and routine vaccination programmes could greatly reduce disease prevalence and the need for antibiotics, most of them were concerned that the necessary capital investment seemed unaffordable. Farmers perceived antibiotics to be necessary: a “worthwhile” and “affordable” investment relative to other interventions. One study reported that the total drug and vaccine cost was less than 4.2% of total production cost per pig (26).

This study showed that farmers, particularly smallholders, have poor knowledge about antibiotics. Several Thai words define “antibiotic” such as 1) “*Ya-Kha-Chue*”: *Ya* = drug, *Kha* = kill, *Chue* = germs, meaning drugs that kill germs; 2) “*Ya-Khae-Akseab*”: *Ya* = drug, *Khae* = anti, *Akseab* = inflammation, meaning drugs that have anti-inflammatory effects; and 3) “*Ya-Pati-Cheewana*”: *Ya* = drug, *Pati* = anti, *Cheewana* = microbes, meaning drugs that counter microbes. This can cause confusion since “antiseptic” has a similar meaning to “drugs that kill germs” as germs can mean many pathogens such as bacteria, protozoa, virus, fungus. Drugs that have anti-inflammatory effects may also refer to anti-inflammatory drugs, and “*Pati-Cheewana*” is a medical term which is not commonly used and understood by lay people.

However, having the relevant knowledge about antibiotics is important but does not guarantee appropriate use. A study in Lithuania found that there was no correlation between level of knowledge and the use of antibiotics in self-medication in people (27). Our previous study in 84 pig farmers also found that there was no association between the use of antibiotics for prevention and CIA, and farmers' knowledge about antibiotics (17).

Smallholder farmers had difficulty seeking professional advice due to a shortage of public veterinary services. The DLD's mission, as a national animal health authority, includes prevention and control of animal disease, law enforcement related to livestock industries and promotion of livestock production (28). However, the limited number of veterinarians in provincial offices and absence of district veterinarians (29) hampered their capacity to support farmers, particularly rural smallholder farmers.

Veterinarians have a key role in providing information about antibiotic use. Farmers reported that veterinarians were the most qualified source of information (24), and key channels to educate farmers about proper use of antibiotics (30). However, lack of surveillance systems for infectious diseases and limited AMR information on livestock were considered to hamper appropriate use of antibiotics by veterinarians. In addition, non-clinical factors influence veterinarians' decisions. In some European countries, veterinarians seldom use sensitivity tests due to the time lag between testing and results (15). Veterinarians have been found to be concerned about business factors including maintaining good relationships with clients (24,31–33), and laboratory diagnosis costs (32). In the human health sector, conflict of interest between healthcare providers and pharmaceutical companies can lead to inappropriate prescribing behaviour and create negative public perceptions towards health professionals (34–37).

Common pharmaceutical company marketing strategies included providing non-educational gifts, advert reprints, support for social outings and conference registration fees (36,37) which may encourage farmers and veterinarians to use antibiotics. In some countries, codes of conduct and ethical guidelines govern the behaviour of pharmaceutical companies (38,39). In the UK animal health system, the Code of Practice for the Promotion of Animal Medicine restricts pharmaceutical promotion related to the sale and prescription of animal medicines (40). However, there are no such codes of conduct or ethical guidelines in Thailand's veterinary sector.

In this study, easy access to antibiotics was a concern, particularly when farmers apply antibiotics to their animals themselves, without veterinary supervision. Recently, in 2019, restrictions for certain veterinary antibiotics were introduced: feed mills can produce medicated feed only through veterinary prescription from the feed distributor or farmer. The farmers who produce farm-mixed medicated feed also need a veterinary prescription, as well as for the use of all pharmaceutical forms including injection and medicated drinking water of quinolones and derivatives, cephalosporins, macrolides and polymyxins (41). A prescription is also needed for the sale of these groups of antibiotics by pharmacies and pharmaceutical companies. However, implementation is still at an early stage and compliance not yet monitored.

The market access rules could help set the private food standards for products, production processes and producers (42,43). The food industry may set up rules for antibiotic residue testing in pig products to maintain quality thru the banning from the markets of animal products with antibiotic residue detected. The regulations in Thailand can further supplement the control of antibiotic use in pig production. By law, animals given an antibiotic cannot be slaughtered until the withdrawal period ends (44) and the maximum residue limit of veterinary drugs in food is set by the Food and Drug Administration (45). It is noteworthy that tightened regulations on the use of antibiotics and the promotion of antibiotic-free meat market may have implications for smallholder pig farm viability. A commercial farm may have higher capacity to replace antibiotic use with other preventive measures such as vaccination and improved infrastructure, while smallholders may have limited capacity to afford the high costs of investment in alternatives to antibiotics. Second, the pig production supply chain potentially limited access of individual/ smallholder farmers to premium markets. Large company pig farmers could produce antibiotic-free pork through their own farms, slaughterhouses and retail shops as well as ensure uninterrupted supplies to premium markets. In contrast, interviews with farmers revealed that antibiotic-free pork and other pork were not managed separately at the slaughterhouse. For example, separate equipment was not used to cut and pack antibiotic-free meat, cleaning practices did not take account of such meat, and traceability information was not kept. This reduced the value to smallholders of meeting an antibiotic-free standard in pig production.

Strengths And Weaknesses Of The Study

To our knowledge, this is the first reported qualitative study in an LMIC which investigates factors influencing the use of antibiotics in pig production. The study attempts to unpack some of the complex interactions among actors involved in antibiotic use, in the context of policy and regulatory environments. Since AMR is a sensitive issue among farmers and other actors in Thailand, the number of farmers who agreed to participate in the study was rather small. In terms of generalisability, the study findings may be useful in other settings that have similar livestock production, markets and regulatory environments.

Policy Recommendations

Our study highlights the need to improve antibiotic use in pig production in Thailand. Given that farmers had limited knowledge and awareness about antibiotics and AMR, access to veterinary services and reliable information about animal health needs to be improved, particularly for smallholder farmers. Innovative low-cost investment in biosecurity could improve farm management leading to effective disease control, improved animal health and decreased reliance on antibiotics. Poor antibiotic prescribing can be addressed through in-service continued professional development and improved undergraduate curricula, and monitoring adherence to clinical guidelines. Controlling the commercial interests of the industry and health professionals in promoting antibiotics will require establishing, enforcing and monitoring a code of conduct. The combination of private market access rules and control through regulations could be an effective instrument to govern the use of antibiotic in livestock production.

Declarations

Consent for publication: The manuscript is not under consideration for publication in another journal, and will not be submitted elsewhere until the BMC Antimicrobial resistance and Infection Control process is completed.

Availability of data and material: The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests: None declared.

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Author Contributions: AL, SY, VT and ML contributed to the design of the study. AM and JR provided conceptual and technical support in the study design and data interpretation phases. AL, VT and ML conducted the analysis and developed the initial draft of the manuscript. All authors substantively reviewed and revised successive drafts and approved the final manuscript.

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Figures

Figure 1

Pigs in the outdoor area at the antibiotic free farm

Figure 2

Potential areas contributing to the use of antibiotics in pig production: roles and perspectives of three actors in a regulatory environment.

Supplementary Files

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